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# SYMPHYTA (HYMENOPTERA) SPECIES RICHNESS IN MIXED OAK-PINE FORESTS IN THE CENTRAL APPALACHIANS

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*Abstract.*—Malaise trap sampling in the George Washington National Forest, Augusta Co., Virginia, and the Monongahela National Forest in Pocahontas Co., West Virginia, in the central Appalachian Mountains over a five-year period at 36 sites resulted in the collection of 155 species in eight families of Symphyta. Tenthredinidae were the most species rich with a total of 121 species and Pergidae were the most abundant with a total of 4,529 specimens. A comparison with other long-term, Malaise trap-based sawfly surveys in diverse habitats indicates that there is a relationship between the number of specimens identified and species richness documented.

*Key Words:* Symphyta, species richness, central Appalachian Mountains

Among insects, larvae of Symphyta are second only to caterpillars (Lepidoptera) as the most commonly encountered foliage-feeding holometabolous insect group. With the exception of one family, the Orussidae, all Symphyta are phytophagous, the majority feeding externally on foliage. While many studies on the diversity and biology of sawflies have been focused on certain economic species and on coniferous pest species, only a few studies have taken a broader approach to the group. Smith and Barrows (1987) sampled sawflies with Malaise traps over a six-year period in urban environments. Smith (1991) documented the diversity of *Macrophya* (Tenthredinidae) sampled over a five-year period in the Piedmont of central Virginia. Sawflies have been included in other Malaise sampling studies that examined total abundance, including comparing trap design in Ontario (Darling and Packer 1988) and general sampling in New York (Matthews and Matthews 1970). A number of unpublished survey reports from Maryland and Virginia has been generated by one of us (DRS) for comparison. The sawfly species collected during our five-year study were taken in the central Appalachian Mountains in mixed oak-pine forests.

This study is part of a larger effort to document potential non-target impacts from aerial application of *Bacillus thuringiensis* Berliner variety *kurstaki* and Gypchek™ in gypsy moth inhabited oak-pine forests in the central Appalachians.

## Materials and Methods

Eighteen 200 ha study plots were set up in the central Appalachian Mountains with nine each in the George Washington National Forest (GWNF) and Monongahela National Forest (MNF) (Fig. 1). The GWNF plots were in Augusta Co., VA,

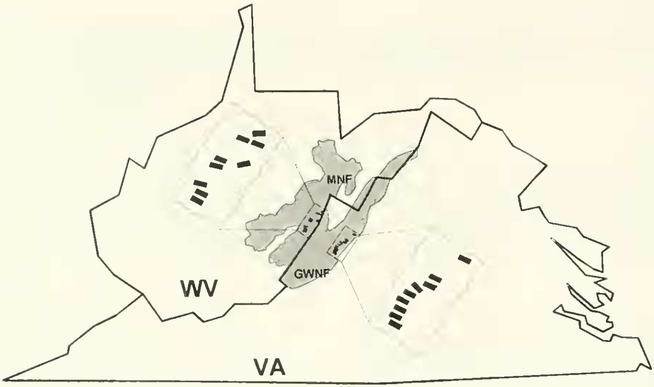


Fig. 1. Location of plots in the George Washington National Forest (GWNF) in Virginia and in the Monongahela National Forest (MNF) in West Virginia.

centered at 38°07′30″N, 79°22′30″W, with traps set at elevations of 561–744 m along the southeast slope of Great North Mountain. The MNF plots were in Pocahontas Co., WV, centered at 38°15′N, 80°00′W, with traps set at elevations of 805–1,232 m. The MNF plots were in groups of three on three different mountains. In addition to oaks (*Quercus* spp.), both sampling areas have high proportions of pines (*Pinus* spp.), hickories (*Carya* spp.), and maples (*Acer* spp.) (Fig. 2). During the sampling period, the MNF study sites had lower average temperatures than the GWNF (Fig. 3). Al-

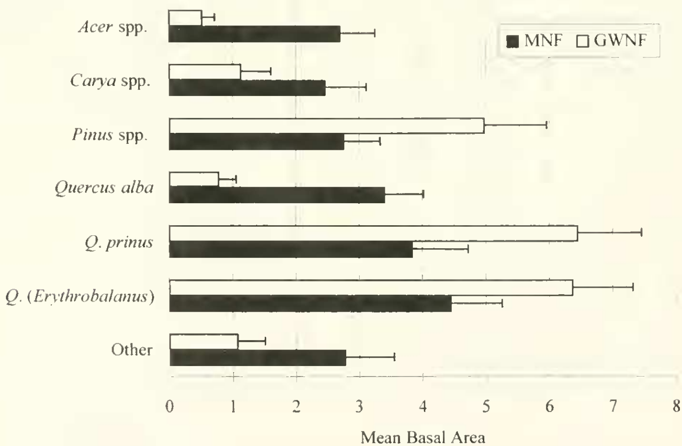


Fig. 2. Abundance of major tree groups as indicated by mean basal area in George Washington National Forest (GWNF) in Virginia and the Monongahela National Forest (MNF) in West Virginia.

though the MNF plots are in a region considered more mesic than the GWNF sampled area (Owenby and Ezell 1992a, b), rainfall during the sampling periods did not clearly reflect this.

A randomly placed 30 ha subplot was established within each study plot. Two Townes-styled Malaise traps (Townes 1972) were set up at different elevations on each subplot, usually with one on a ridge, the other in a valley. Traps were placed on south facing slopes or ridges, and the length oriented east-west with the collecting head up slope. Fifteen weekly samples were taken from mid-May to mid-August from 1995 to 1999. Adult Symphyta were extracted from samples and identified by D.R. Smith. Voucher specimens are deposited in the West Virginia University Arthropod Collection, Morgantown, and the National Museum of Natural History, Smithsonian Institution, Washington, DC.

## Results and Discussion

Over the five years of sampling with 36 Malaise traps, a total of 8,884 adult sawflies were collected and identified to 155 species (Table 1). Species richness was less on the GWNF plots than on the MNF plots, with 104 and 127 species identified, respectively (Table 2). Eight families of sawflies were represented, with the Tenthredinidae by far the most diverse with 121 species, followed by the Pamphiliidae with 14 species. Tenthredinidae abundance with 4,240 individuals was less than Pergidae abundance of 4,529 specimens.

There are some distinct differences between the GWNF and MNF study plots that may influence their respective species richness, including elevation, rainfall, and perhaps most importantly, the distribution of the study plots. These factors, in turn, likely influence the plant species present. The GWNF plots are regularly arranged along the broad southeast slope of Great North Mountain, with 23 tree species identified. In contrast, the MNF study plots are scattered on three mountains with various aspects, with a total of 31 tree species identified. Many of the sawflies collected were not tree herbivores, but the eight additional tree species on the MNF plots suggested a greater general plant diversity at MNF and this likely influenced the total sawfly species richness.

The total richness of 155 species is similar to the 117 species reported by Smith and Barrows (1987) in the Washington, DC, metropolitan area environments, located approximately 200 km northeast of the GWNF and MNF plots. Smith and Barrows sampled for six years at two sites in urban environments and two years at two sites in lesser developed environments using similar styled Malaise traps. In terms of specimens examined, they required only 948 specimens to reach 117 species, and the present study included 8,884 specimens. In addition to different trap design and vegetation at the study sites, it should be noted that Smith and Barrows sampled from late March to early November, whereas our sampling period was from mid-May to mid-August; thus, we possibly missed species that fly only in early spring or late summer and fall. This, along with a great variety of environments, may account for the richness Smith and Barrows sampled with less effort.

Smith (1991) studied the species richness of *Macrophya* Dahlbom (Tenthredinidae) over a five-year period with up to 12 Townes-style Malaise traps per year in a 550 acre area in central Virginia. He identified 28 of 44 *Macrophya* species known east of the Rockies (Gibson 1980), compared with 16 species in our study. Although our trapping periods overlapped with the typical flight times of *Macrophya* (Smith 1991), the known host plants (primarily *Sambucus* spp. and *Viburnum* spp.) were not common on our sites as they were on Smith's central Virginia site.

In Malaise samples taken in a New York mesic forest, Matthews and Matthews (1970) found that Tenthredinidae was the most abundant hymenopteran family, other

Table 1. Family species richness sampled 1995–1999 in the George Washington National Forest (G) in Virginia and in the Monongahela National Forest (M) in West Virginia.

Argidae

*Arge macleayi* (Leach)[G,M], *Arge pectoralis* (Leach)[G,M], *Arge quidia* Smith[G,M], *Arge willi* Smith[G,M], *Schizocerella pilicornis* (Holmgren)[G], *Sphacophilus celluaris* (Say)[G], *Sterictiphora serotina* Smith[G]

Cephidae

*Janus abbreviatus* (Say)[M], *Janus bimaculatus* (Norton)[G], *Janus integer* (Norton)[G,M]

Diprionidae

*Neodiprion* sp. (male)[G]

Pamphiliidae

*Acantholyda angulata* (MacGillivray)[M], *Acantholyda luteomaculata* (Cresson)[M], *Acantholyda zappei* (Rohwer)[G], *Neurotoma fasciata* (Norton)[G], *Onycholyda luteicornis* (Norton)[G,M], *Onycholyda quebecensis* (Provancher)[G], *Onycholyda rufofasciatus* (Norton)[M], *Pamphilius middlekauffi* Shinohara & Smith[G], *Pamphilius ochreipes* (Cresson)[G], *Pamphilius pallimaculus* (Norton)[G,M], *Pamphilius persicum* MacGillivray[M], *Pamphilius phyllisae* Middlekauff[M], *Pamphilius rileyi* (Cresson)[G,M], *Pamphilius semicinctus* (Norton)[M]

Pergidae

*Acordulecera dorsalis* Say[G,M], *Acordulecera maculata* MacGillivray[G,M], *Acordulecera mellina* MacGillivray[G,M], *Acordulecera pellucida* (Konow)[G,M]

Tenthredinidae

*Aglaostigma quattuordecimpunctatum* (Norton)[G,M], *Aglaostigma semiluteum* (Norton)[M], *Aglaostigma* sp. #1[M], *Ametastegia aperta* (Norton)[G,M], *Ametastegia becra* Smith[G,M], *Ametastegia pallipes* (Spinola)[M], *Ametastegia pulchella* (Rohwer)[G,M], *Aneugmenus flavipes* (Norton)[G,M], *Caliroa lobata* MacGillivray[G], *Caliroa lunata* MacGillivray[G,M], *Caliroa obsoleta* (Norton)[M], *Caliroa quercuscoccinea* (Dyar)[G,M], *Caliroa* spp. (males)[G,M], *Caulocampus acericaulis* (MacGillivray)[M], *Craterocercus fraternalis* (Norton)[G,M], *Craterocercus obtusus* (Klug)[G,M], *Dimorphopteryx pinguis* (Norton)[G,M], *Dimorphopteryx virginicus* Rohwer[M], *Dolerus hebes* Goulet[G], *Dolerus nortoni* Ross[M], *Empria coryli* (Dyar)[M], *Empria maculata* (Norton)[G,M], *Empria multicolor* (Norton)[G,M], *Erythraspides vitis* (Harris)[G], *Eupareophora parca* (Cresson)[M], *Eutomostethus ephippium* (Panzer)[G,M], *Fenusa ulmi* Sundevall[M], *Halidamia affinis* (Fallen)[M], *Hemichroa militaris* (Cresson)[M], *Hemitaxonus albidopictus* (Norton)[G,M], *Hemitaxonus dubitatus* (Norton)[M], *Hoplocampa halcyon* (Norton)[M], *Hoplocampa marlatti* (Rohwer)[G,M], *Leucopelmonus annulicornis* (Harrington)[G,M], *Macremphytus tarsatus* (Say)[G] *Macremphytus testaceus* (Norton)[G,M], *Macrophya cassandra* Kirby[G,M], *Macrophya flavicoxae*(Norton)[M]

Table 1. Continued.

*Macrophya flavolinea* (Norton)[M], *Macrophya flavolineata* (Norton)[M], *Macrophya flicta* MacGillivray[G], *Macrophya formosa* (Klug)[G,M], *Macrophya goniphora* (Say)[G,M], *Macrophya lineata* (Norton)[M], *Macrophya macgillivrayi* Gibson[M], *Macrophya masoni* Gibson[G], *Macrophya mensa* Gibson[G], *Macrophya nigra* (Norton)[G,M], *Macrophya pulchella* (Klug)[G,M], *Macrophya tibiator* Norton[G,M], *Macrophya trisyllaba* (Norton)[M], *Macrophya varia* (Norton)[G], *Monophadnoides geniculatus* (Hartig)[G,M], *Monophadnoides pauper* (Provancher)[G,M], *Monophadnus aequalis* MacGillivray[G,M], *Monophadnus bakeri* Smith[M], *Monophadnus conspiculatus* MacGillivray[G], *Monophadnus pallescens* (Gmelin)[M], *Monostegia abdominalis* (F.)[M], *Nefusa ambigua* (Norton)[G,M], *Nematus* sp. #1[G,M], *Nematus* sp. #2[G,M], *Nematus* sp. #3[G,M], *Nematus* sp. #4[G,M], *Nematus abbotii* (Kirby)[G,M], *Nematus carpini* (Marlatt)[M], *Nematus coryli* Cresson[M], *Nematus latifasciatus* Cresson[M], *Nematus lipovskyi* Smith[G,M], *Nematus* near *actriceps* (Marlatt)[G,M], *Nematus ostryae* (Marlatt)[G,M], *Nematus radialis* Smith[G,M], *Nematus tibialis* Newman[G,M], *Neopareophora litura* (Klug)[G,M], *Pachynematus* sp. #1[M], *Pachynematus* sp. #2[G], *Pachynematus corniger* (Norton)[G,M], *Pachynematus extensicornis* (Norton)[G], *Paracharactus rudis* (Norton)[G,M], *Periclista albicollis* (Norton)[G,M], *Periclista diluta* (Cresson)[G,M], *Periclista inaequidens* (Norton)[M], *Periclista marginicollis* (Norton)[G,M], *Periclista media* (Norton)[G,M], *Periclista stannardi* Smith[M], *Phymatocera fumipennis* (Norton)[M], *Priophorus pallipes* (Lepeletier)[G,M], *Pristiphora banksi* Marlatt[G,M], *Pristiphora bivittata* (Norton)[G], *Pristiphora chlorea* (Norton)[G,M], *Pristiphora cincta* (Newman)[G,M], *Pristiphora mollis* (Hartig)[M], *Pristiphora rufipes* Lepeletier[M], *Pristiphora* sp. #1[M], *Pristiphora zella* Rohwer[G], *Profenusa alumna* (MacGillivray)[G,M], *Pseudodineura parva* (Norton)[M], *Strongylogaster impressata* Provancher[M], *Strongylogaster multicincta* Norton[G], *Strongylogaster polita* Cresson[G], *Strongylogaster soriculatipes* Cresson[G], *Strongylogaster tacita* (Norton)[M], *Taxonus borealis* MacGillivray[G,M], *Taxonus epicera* (Say)[G,M], *Taxonus pallicoxus* (Provancher)[G,M], *Taxonus pallidicornis* (Norton)[G,M], *Taxonus pallipes* (Say)[G,M], *Taxonus proximus* (Provancher)[G,M], *Taxonus rufocinctus* (Norton)[G,M], *Taxonus spiculatus* (MacGillivray)[G,M], *Taxonus terminalis* (Say)[G,M], *Tenthredo appalachia* Goulet & Smith[M], *Tenthredo fernowi* Goulet & Smith[G], *Tenthredo grandis* (Norton)[M], *Tenthredo lobata* (Norton)[G], *Tenthredo masneri* Goulet & Smith[M], *Tenthredo mellicoxa* (Provancher)[M], *Tenthredo rufopecta* (Norton)[G,M], *Tenthredo* sp. #1[M], *Tenthredo verticalis* Say[M], *Tenthredo yuasi* MacGillivray[G,M]

Xiphydriidae

*Xiphydria abdominalis* Say[M], *Xiphydria maculata* Say[M], *Xiphydria tibialis* Say[G,M]

Xyelidae

*Xyela alpigena* (Strobl)[G,M], *Xyela* sp. (males)[G,M]

Table 2. Family species richness sampled 1995–1999 in the George Washington National Forest (GWNF) in Virginia and in the Monongahela National Forest (MNF) in West Virginia.

| Family | Richness | | |
|---|---|---|---|
| | GWNF | MNF | Total |
| Argidae | 7 | 4 | 7 |
| Cephidae | 2 | 2 | 3 |
| Diprionidae | 1 | 0 | 1 |
| Pamphiliidae | 8 | 9 | 14 |
| Pergidae | 4 | 4 | 4 |
| Tenthredinidae | 79 | 103 | 121 |
| Xiphydriidae | 1 | 3 | 3 |
| Xyelidae | 2 | 2 | 2 |
| Total | 104 | 127 | 155 |

than Ichneumonidae. Smith and Barrows (1987) found the Tenthredinidae to be relatively abundant as well in urban environments, with 590 of the 948 sawflies sampled belonging to this family. Our study also found high abundance of Tenthredinidae, although Pergidae were most abundant, with a single species, *Acordulecera dorsalis* Say, accounting for more than half of the sawflies (4,481 specimens). Two of the preferred hosts of *A. dorsalis*, oaks and hickories, are common trees on our study plots and undoubtedly account for the high abundance of *A. dorsalis*.

D. R. Smith or D. R. Smith and E. M. Barrows have surveyed sawflies in various settings in Maryland and Virginia (D. R. Smith, unpublished data). These studies are similar to their Washington, DC, survey (Smith and Barrows 1987) and the present study in that these surveys with Malaise traps were during most or all of the sawfly flight times for the area surveyed over multiple years. The studies vary in number of traps used, number of years sampled, and numerous habitat characteristics (Table 3). Even with these variables, an interesting correlation exists between the number of specimens identified and the sampled species richness (Fig. 4). The plotted data with just six data points does not show an asymptote to suggest an approximate sample size that may be adequate to estimate species richness in diversely vegetated environments. It only suggests that it may be somewhere above approximately 9,000 specimens. It should be noted that when surveying a highly diverse taxon like the Symphyta with more than 1,100 species in North America (Smith 1979), that passive traps will collect species normally not found at the trapping site. It may be that these "accidentals" and rare species account for the strong sample size-species

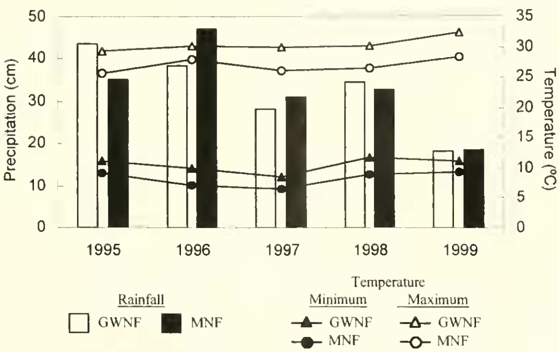


Fig. 3. Temperature and rainfall measurements from mid-May through mid-August for years 1995–1999 in the George Washington National Forest (GWNF) in Virginia and in the Monongahela National Forest (MNF) in West Virginia.

Table 3. Comparison of richness of Symphyta sampled at some survey sites, counts of specimens identified, number of Malaise traps used, and number of years sampled.

| Study Area | General Description of Sampling Area | Species Richness | Specimens Identified | Number of Traps | Years of Sampling | Years |
|---|---|---|---|---|---|---|
| Green Ridge State Park, Allegheny Co., MD (E. Barrows, D.R. Smith) | oak-hickory forest, flood plain to ridge | 118 | 3,033 | 6 | 3 | 1990–1992 |
| Finzel Swamp, Garrett Co., MD (E. Barrows, D.R. Smith) | open field, forest edge, swamp edge | 139 | 5,397 | 2 | 2 | 1991–1992 |
| Beltsville Agricultural Research Center, MD (D.R. Smith) | bog, coniferous, deciduous, bottomland | 152 | 8,907 | 3–4 | 3 | 1991–1993 |
| UV Blandy Experimental Farm and State Arboretum, Clarke, Co. VA (D.R. Smith) | forest, forest edges, pond edges | 189 | 21,378 | 5–11 | 4 | 1990–1993 |
| Washington, DC and vicinity (Smith and Barrows 1987) | various urban environments | 117 | 948 | 5–8 | 2–6 | 1980–1986 |
| G. Washington and Monongahela National Forests, VA, WV | oak-pine forests | 155 | 8,884 | 36 | 5 | 1995–1999 |

richness correlation. Further examination of the unpublished data may explain the apparent relationship.

One of the distinct differences between these studies is the number of Malaise traps used. In our study, we used 36 traps placed in similar forest environments. The two to 11 traps used in the other studies were generally placed along forest margins or in open areas, taking advantage of open flight

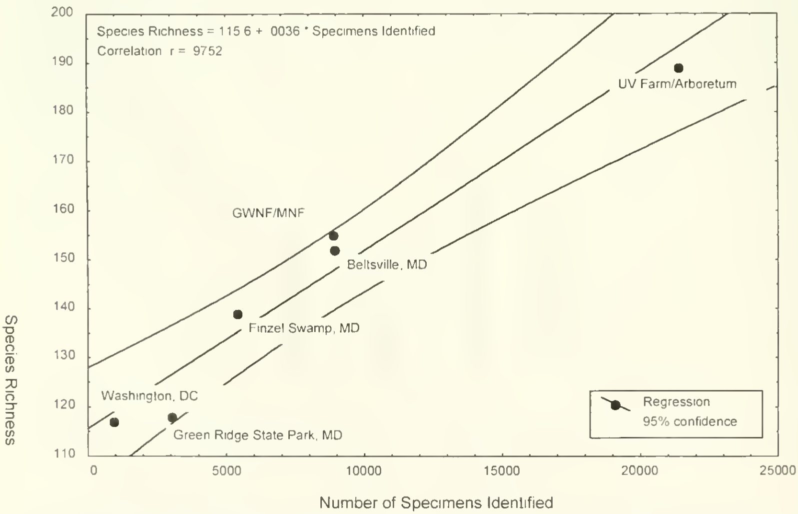


Fig. 4. Regression analysis of species richness and specimens identified in published and unpublished surveys of Symphyta. See Table 3 for study areas.

paths, increased sunlight, and areas of potentially greater host plant diversity. Traps placed in transition zones (i.e., forest margins) may quickly realize large, species-rich samples, but additional traps on either side of transition zones need to be included for more habitat-specific study.

In conclusion, Malaise trapping is effective in collecting large numbers of sawflies to estimate species richness. The species richness of sawflies in old, secondary growth in the central Appalachian Mountains is comparable with other plant species-rich habitats in adjacent areas. In addition, these surveys may indicate that in long-term studies, specimen counts are the most important variable to document taxonomically diverse insect taxa in host or prey species-rich habitats.

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